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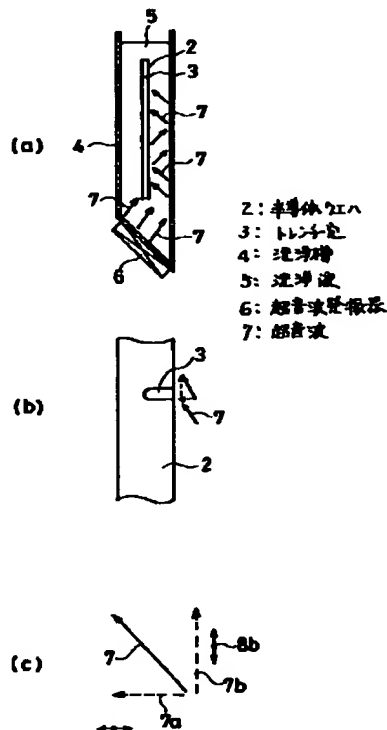
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(54)【発明の名称】 半導体装置の洗浄方法

(57) 【要約】

【目的】 半導体ウエハの表面や半導体ウエハに形成された穴、溝内にある異物を超音波のエネルギーの助けにより剥離し、液体の分子運動により異物を外部に排出し、異物を完全に除去するものである。

【構成】 半導体ウエハに形成された穴や溝に対し、水平成分と垂直成分を持つ超音波を照射し、液体分子を振動させて洗浄するものである。



1

## 【特許請求の範囲】

【請求項1】 半導体ウエハに形成された穴や溝に対し、水平成分と垂直成分を持つ超音波を照射し、液体分子を振動させて洗浄することを特徴とする半導体装置の洗浄方法。

## 【発明の詳細な説明】

## 【0001】

【産業上の利用分野】この発明は半導体装置の洗浄方法に関し、特に半導体ウエハに形成された穴や溝内に付着した異物を除去することができる半導体装置の洗浄方法に関する。

## 【0002】

【従来の技術】近時、半導体装置例えば半導体集積回路の微細化が進み、半導体ウエハの表面に形成される回路の構造が複雑になり、表面のおおとつが激しくなっている。このため、図5に示すように異物1が半導体ウエハ2の表面に形成されたトレンチ穴3の開口部近傍や中間部以降の壁面に沿って残る。そこで、半導体集積回路を製造する各工程において、ウエハ表面上の異物1を除去するのみではなく、おおとつの激しい部分例えばアスペクト比の大きさが数十程度のトレンチ穴や溝内における異物も確実に除去する必要がある、例えば純水リンスを用いて60分洗浄したのち自乾した場合、図6

(a)に示すようにウエハ表面に付着していたパーティクルが剥離しているが、異物1がいぜんとして残っている。また、SC-1で5分、純水リンスで5分洗浄したのち自乾した場合、図6(b)に示すように半導体ウエハ2の表面には異物1が無くなるが、トレンチ穴3内にはいぜんとして残っている。

## 【0003】

【発明が解決しようとする課題】しかしながら、上述した従来の半導体装置の洗浄方法はトレンチ穴の中の異物を完全に除去する有効な手段がなく、いぜんとして異物が残るといった問題点があった。この発明は上記のような問題点を解消するためになされたもので、超音波による洗浄液の分子運動により半導体ウエハの表面、穴および溝の内にある異物を除去することを目的とする。

## 【0004】

【課題を解決するための手段】この発明に係る半導体装置の洗浄方法は、半導体ウエハに形成された穴や溝に対し、水平成分と垂直成分を持つ超音波を照射し、液体分子を振動させて洗浄するものである。

## 【0005】

【作用】この発明は半導体ウエハの表面、穴および溝の内にある異物を、超音波のエネルギーの助けにより、洗浄液の分子運動（異物と同程度の大きさ）により、穴、溝の内から外に出したのち、外部へ完全に除去することができる。

## 【0006】

2

の一実施例を示す図であり、特に図1(a)はその断面側面図、図1(b)および図1(c)は図1(a)における洗浄動作を説明するための図である。同図において、4は洗浄液5を入れた洗浄槽、6はこの洗浄槽4の壁面に取り付けられ、超音波7を出力する超音波発振器であり、一例として、超音波7が半導体ウエハ2の表面に所定の角度で照射するように超音波発振器6を取り付けた場合であり、一例として洗浄槽4の取付け壁面を傾斜させて、超音波発振器6を取り付けた場合である。

【0007】次に上記構成による半導体装置の洗浄方法、特にトレンチ穴3の内を洗浄し、異物を除去する動作について図1(b)および図1(c)を参照して説明する。まず、トレンチ穴3をもつ半導体ウエハ2の表面から見ると、超音波7は図1(b)に示すようにトレンチ穴3に対し水平成分7aと垂直成分7bとに分けることができる。したがって、この超音波7の水平成分7aは図1(c)に示すように、トレンチ穴3内の洗浄液5を水平方向8aに振動させて、トレンチ穴3内の異物1を剥離させ、トレンチ穴3の外に異物を排出する。一方、超音波7の垂直成分7bは図1(c)に示すようにトレンチ穴3内の洗浄液5を垂直方向8bに振動し、半導体ウエハ2の表面に排出された異物1を半導体ウエハ2の表面から遠ざけるように作用する。

【0008】なお、半導体ウエハ2に対する超音波発振器6の取り付け角度は20度～70度程度にすることにより、トレンチ穴3内の異物1を効率よく剥離し、排出することができる。図7では(SC-1)+(MS)で10分洗浄し、そして純水リンスで5分洗浄したのち自乾した場合であり、トレンチ穴3内および半導体ウエハ表面共にパーティクルの残留はなしである

【0009】図2はこの発明に係る半導体装置の洗浄方法の他の実施例を示す図であり、特に図2(a)はその断面側面図、図2(b)および図2(c)は図2(a)における洗浄動作を説明するための図である。同図において、9a～9dはトレンチ穴3に対して水平方向の超音波10を出力する第1超音波発振器、11はトレンチ穴3に対して垂直方向の超音波12を出力する第2超音波発振器である。なお、半導体ウエハ2の表面に付着した異物およびトレンチ穴3内にある異物1を剥離し、除去する動作は図1の動作と同様であることはもちろんである。

【0010】次に、トレンチ穴3内の異物1を除去するための超音波の周波数(MHZ)とパワー(W/cm<sup>2</sup>)の関係を図3および図4を参照して説明する。まず、トレンチ穴3の中の異物1を除去するためには、(A) トレンチ穴3内に洗浄液5の分子流13にエネルギーを伝えるため、トレンチ穴3の径より小さい振幅をもつ超音波、(B) 洗浄液5の分子流13によりトレンチ穴3内の異物1を振動させて剥離させることおよびトレ

3

拌を加速し、トレンチ穴3の外へ異物1を排出するため、半導体ウエハ2の表面に垂直（トレンチ穴3に対して水平）で、かつ異物1と同程度の振動幅をもつ超音波、（C）半導体ウエハ2の表面に排出された異物1を洗浄液5の分子流13により半導体ウエハ2の表面における洗浄液5のかく拌を加速し、半導体ウエハ2の表面より遠ざけるため、半導体ウエハ2の表面に水平（トレンチ穴3に対して垂直）でかつ異物1と同程度の振動幅をもつ超音波により可能である。そこで、超音波の音響パワー（ $I: W/cm^2$ ）と周波数（ $f$ ）と洗浄液5の分子振動幅（ $A: cm$ ）との関係は下記に示すことができる。

$$【0011】 I = PC (2\pi f A)^2 / 2$$

ただし、Pは洗浄液（5）の密度（ $g/cm^3$ ）（水の場合は1）

Cは音速（ $cm/S$ ）（水の場合は $1.5 \times 10^5$ （ $cm/S$ ））

【0012】  $1\mu m$ の幅のトレンチ穴3内の $0.06\mu m$ 異物1を効率よく取り除くとして、 $0.06\mu m$ の液分子振動幅を得るためには上記の式から周波数800KHz、音響パワー $7.5W/cm^2$ が必要である。そして、振動幅 $0.01\mu m$ 、 $0.06\mu m$ 、 $0.5\mu m$ を得る場合の周波数と音響パワーとの関係を図4に示す。また、 $1\mu m$ の幅のトレンチ穴（3）内の異物（ $0.5\mu m \sim 0.01\mu m$ ）を取り除くには100KHz～10MHzの周波数と $0.01 \sim 4,000W/cm^2$ の音響エネルギーをトレンチ穴3に対して、垂直成分および水平成分を持つ超音波をウエハ表面に加える必要がある。

【0013】

【発明の効果】以上詳細に説明したように、この発明に係る半導体装置の洗浄方法によれば、半導体ウエハに形

4

成された穴、溝内および表面に付着した異物を超音波および液流による液の運動エネルギーで剥離し、外部に完全に排出することができる効果がある。

【図面の簡単な説明】

【図1】この発明に係る半導体装置の洗浄方法の一実施例を示す図である。

【図2】この発明に係る半導体装置の洗浄方法の他の実施例を示す図である。

【図3】半導体ウエハのトレンチ穴内の異物除去の方法を示す図である。

【図4】液の分子振動幅と超音波音響エネルギー、周波数との関係を示す図である。

【図5】トレンチ穴内にある異物の標準汚染サンプルを示す図である。

【図6】従来の半導体装置の洗浄方法によりトレンチ穴内およびウエハ表面を洗浄した場合を示す図である。

【図7】この発明に係る半導体装置の洗浄方法によりトレンチ穴内およびウエハ表面を洗浄した場合を示す図である。

【符号の説明】

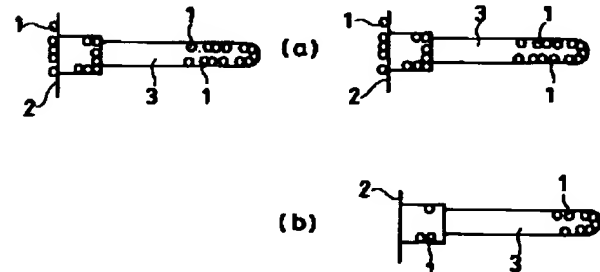
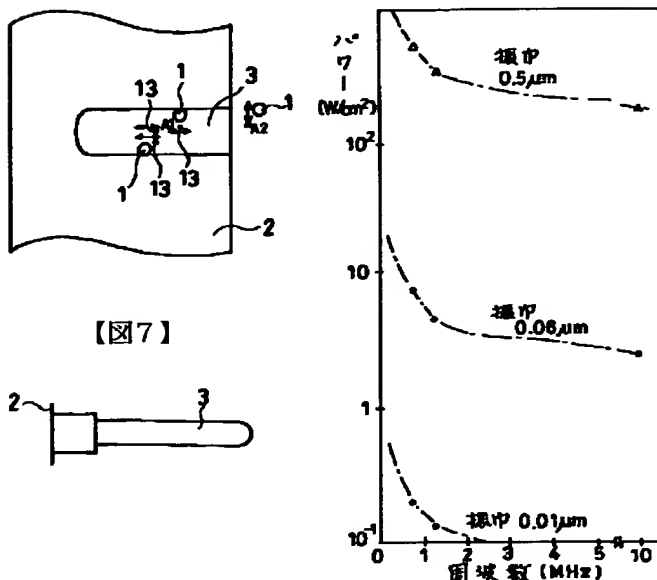
- 1 異物
- 2 半導体ウエハ
- 3 トレンチ穴
- 4 洗浄槽
- 5 洗浄液
- 6 超音波発振器
- 7 超音波
- 8a, 8b 洗浄液の振動方向
- 10, 12 超音波
- 9a～9b, 11 超音波発振器

【図3】

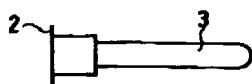
【図4】

【図5】

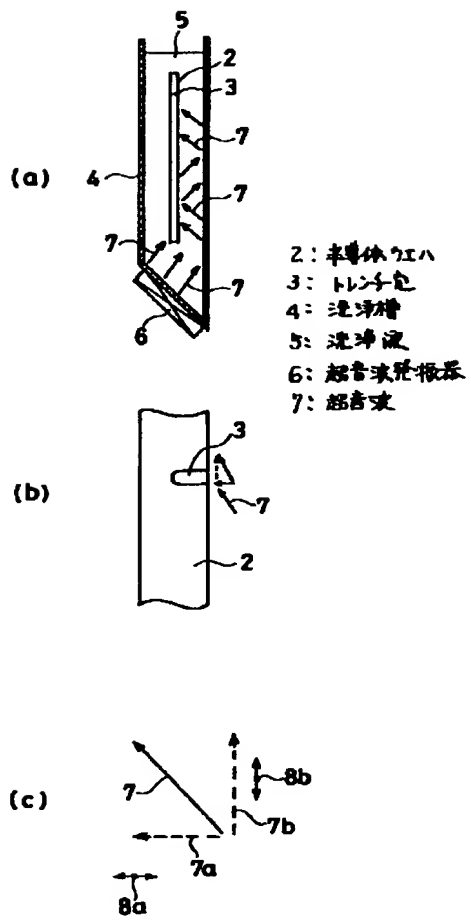
【図6】



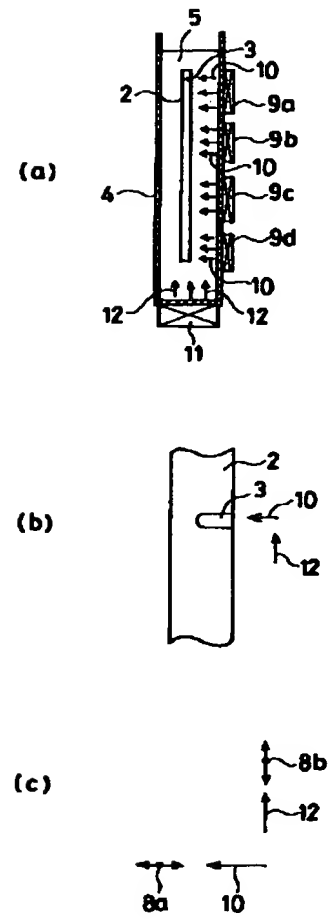
【図7】



【図1】



【図2】



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## PATENT ABSTRACTS OF JAPAN

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(22)Date of filing : 09.07.1991

(72)Inventor : IKEDA TOSHIHARU  
OMORI MASASHI

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### (54) CLEANING METHOD FOR SEMICONDUCTOR DEVICE

#### (57)Abstract:

PURPOSE: To remove completely foreign substances by a method wherein a hole or a groove formed in a semiconductor wafer is irradiated with ultrasonic waves, each having a horizontal component and a vertical component, and the foreign substances are discharged outside by the molecular motion of a liquid.

CONSTITUTION: An ultrasonic oscillator 6 is mounted on the wall surface of a cleaning tank 4, in which a cleaning liquid 5 is put. The oscillator 6 is mounted in such a way that the surface of a semiconductor wafer 2 is irradiated with ultrasonic waves 7 at a prescribed angle. For example, the mounting wall surface of the tank 4 is slanted to mount the oscillator 6. The waves 7 respectively have a horizontal component 7a and a vertical component 7b to a trench hole 3 as seen from the surface of the wafer 2 having the trench hole 3. The component 7a makes the liquid 5 in the hole 3 vibrate in horizontal directions 8a to eliminate foreign substances in the hole 3. The component 7b makes the liquid 5 in the hole 3 vibrate in vertical directions 8b to keep foreign substances discharged on the surface of the wafer 2 away from the surface of the wafer 2. Thereby, residues of particles in the hole 3 and on the wafer surface are eliminated.

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### LEGAL STATUS

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3. In the drawings, any words are not translated.

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**CLAIMS**

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[Claim(s)]

[Claim 1] The washing method of the semiconductor device characterized by irradiating an ultrasonic wave with a horizontal component and a vertical component to the hole and slot which were formed in the semiconductor wafer, vibrating a liquid molecule, and washing.

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[Translation done.]

[JP,05-013396,A]

1.

## TECHNICAL FIELD

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[Industrial Application] Especially this invention relates to the washing method of a semiconductor device that the foreign matter adhering to the hole formed in the semiconductor wafer or Mizouchi is removable, about the washing method of a semiconductor device.

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[Translation done.]

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## 1. TECHNICAL PROBLEM

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[Problem(s) to be Solved by the Invention] However, the washing method of the conventional semiconductor device mentioned above does not have an effective means to remove the foreign matter in a trench hole completely, and had the trouble that still carried out and a foreign matter remained. This invention was made in order to cancel the above troubles, and it aims at removing the foreign matter which is in the inside of the front face of a semiconductor wafer, a hole, and a slot by the molecular motion of the penetrant remover by the ultrasonic wave.

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[Translation done.]

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## 1. OPERATION

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[Function] With the help of the energy of an ultrasonic wave, by the molecular motion (size of the same grade as a foreign matter) of a penetrant remover, this invention can remove it completely to the exterior, after taking out the foreign matter in the inside of the front face of a semiconductor wafer, a hole, and a slot from from outside among a hole and a slot.

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[Translation done.]

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## 1. MEANS

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[Means for Solving the Problem] The washing method of the semiconductor device concerning this invention irradiates an ultrasonic wave with a horizontal component and a vertical component to the hole and slot which were formed in the semiconductor wafer, vibrates a liquid molecule, and is washed.

---

[Translation done.]

---

## 1. OPERATION

---

[Function] With the help of the energy of an ultrasonic wave, by the molecular motion (size of the same grade as a foreign matter) of a penetrant remover, this invention can remove it completely to the exterior, after taking out the foreign matter in the inside of the front face of a semiconductor wafer, a hole, and a slot from from outside among a hole and a slot.

---

[Translation done.]

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## PRIOR ART

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[Description of the Prior Art] the structure of the circuit which detailed-ization of a semiconductor device, for example, a semiconductor integrated circuit, progresses recently, and is formed in the front face of a semiconductor wafer -- complicated -- becoming -- a front face -- \*\*\*\* -- a convex is becoming intense For this reason, it remains along with the wall surface after the pars intermedia near the opening of the trench hole 3 where the foreign matter 1 was formed in the front face of the semiconductor wafer 2 as shown in drawing 5 . In each process which manufactures a semiconductor integrated circuit then, it not only removes the foreign matter 1 on a wafer front face, but It is necessary to also remove certainly the foreign matter in the trench hole and Mizouchi whose sizes of the intense portion of a convex, for example, an aspect ratio, are about dozens. \*\*\*\* -- For example, although the particle adhering to the wafer front face has exfoliated as shown in drawing 6 (a) when [ which was washed for 60 minutes using the pure water rinse ] it after self-\*\*, the foreign matter 1 still carried out and remains. Moreover, although a foreign matter 1 is lost in the front face of the semiconductor wafer 2 as shown in



drawing 6 (b) when [ which was washed with the pure water rinse by SC-1 for 5 minutes for 5 minutes ] it after self-\*\*, in the trench hole 3, it still carried out and remains.

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[Translation done.]

## DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Industrial Application] Especially this invention relates to the washing method of a semiconductor device that the foreign matter adhering to the hole formed in the semiconductor wafer or Mizouchi is removable, about the washing method of a semiconductor device.

[0002]

[Description of the Prior Art] the structure of the circuit which detailed-ization of a semiconductor device, for example, a semiconductor integrated circuit, progresses recently, and is formed in the front face of a semiconductor wafer -- complicated -- becoming -- a front face -- \*\*\*\* -- a convex is becoming intense For this reason, it remains along with the wall surface after the pars intermedia near the opening of the trench hole 3 where the foreign matter 1 was formed in the front face of the semiconductor wafer 2 as shown in drawing 5 . In each process which manufactures a semiconductor integrated circuit then, it not only removes the foreign matter 1 on a wafer front face, but It is necessary to also remove certainly the foreign matter in the trench hole and Mizouchi whose sizes of the intense portion of a convex, for example, an aspect ratio, are about dozens. \*\*\*\* -- For example, although the particle adhering to the wafer front face has exfoliated as shown in drawing 6 (a) when [ which was washed for 60 minutes using the pure water rinse ] it after self-\*\*, the foreign matter 1 still carried out and remains. Moreover, although a foreign matter 1 is lost in the front face of the semiconductor wafer 2 as shown in drawing 6 (b) when [ which was washed with the pure water rinse by SC-1 for 5 minutes for 5 minutes ] it after self-\*\*, in the trench hole 3, it still carried out and remains.

[0003]

[Problem(s) to be Solved by the Invention] However, the washing method of the conventional semiconductor device mentioned above does not have an effective means to remove the foreign matter in a trench hole completely, and had the trouble that still carried out and a foreign matter remained. This invention was made in order to cancel the above troubles, and it aims at removing the foreign matter which is in the inside of the front face of a semiconductor wafer, a hole, and a slot by the molecular motion of the penetrant remover by the ultrasonic wave.

[0004]

[Means for Solving the Problem] The washing method of the semiconductor device concerning

this invention irradiates an ultrasonic wave with a horizontal component and a vertical component to the hole and slot which were formed in the semiconductor wafer, vibrates a liquid molecule, and is washed.

[0005]

[Function] With the help of the energy of an ultrasonic wave, by the molecular motion (size of the same grade as a foreign matter) of a penetrant remover, this invention can remove it completely to the exterior, after taking out the foreign matter in the inside of the front face of a semiconductor wafer, a hole, and a slot from from outside among a hole and a slot.

[0006]

[Example] Drawing 1 is drawing showing one example of the washing method of the semiconductor device concerning this invention, and especially drawing 1 (a) is drawing for the cross-section side elevation, drawing 1 (b), and drawing 1 (c) explaining washing operation in drawing 1 (a). The washing tub into which 4 put the penetrant remover 5 in this drawing, and 6 are the cases where were the ultrasonic wave oscillator which outputs an ultrasonic wave 7, are the case where a ultrasonic wave oscillator 6 is attached, made the anchoring wall surface of the washing tub 4 to have been attached in the wall surface of this washing tub 4, and incline as an example so that an ultrasonic wave 7 may irradiate the front face of the semiconductor wafer 2 at an angle of predetermined as an example, and a ultrasonic wave oscillator 6 is attached.

[0007] Next, the inside of the washing method of the semiconductor device by the above-mentioned composition, especially the trench hole 3 is washed, and operation which removes a foreign matter is explained with reference to drawing 1 (b) and drawing 1 (c). First, if it sees from the front face of the semiconductor wafer 2 with the trench hole 3, an ultrasonic wave 7 can be divided into horizontal component 7a and vertical-component 7b to the trench hole 3, as shown in drawing 1 (b). Therefore, as shown in drawing 1 (c), horizontal component 7a of this ultrasonic wave 7 vibrates the penetrant remover 5 in the trench hole 3 to horizontal direction 8a, makes the foreign matter 1 in a trench 3 exfoliate, and discharges a foreign matter outside the trench hole 3. On the other hand, vertical-component 7b of an ultrasonic wave 7 vibrates the penetrant remover 5 in the trench hole 3 to perpendicular direction 8b, as shown in drawing 1 (c), and it acts so that the foreign matter 1 discharged by the front face of the semiconductor wafer 2 may be kept away from the front face of the semiconductor wafer 2.

[0008] In addition, by making it 20 - about 70 degrees, the degree of setting angle of the ultrasonic wave oscillator 6 to the semiconductor wafer 2 exfoliates efficiently, and can discharge the foreign matter 1 in the trench hole 3. It is

[0009] without the inside of a trench 3 and a semiconductor wafer front face. [ at drawing 7 , wash by (SC-1)+ (MS) for 10 minutes, and are the case washed with the pure water rinse for 5 minutes where it after self-\*\*, and ] [ remains of particle ] Drawing 2 is drawing showing other examples of the washing method of the semiconductor device concerning this invention, and especially drawing 2 (a) is drawing for the cross-section side elevation, drawing 2 (b), and drawing 2 (c) explaining washing operation in drawing 2 (a). Set to this drawing. The 1st ultrasonic wave oscillator which outputs the horizontal ultrasonic wave 10 to the trench hole 3 9a-9d, and 11 are the 2nd ultrasonic wave oscillator which outputs the vertical ultrasonic wave 12 to the trench hole 3. In addition, of course, operation which exfoliates and removes the foreign

matter 1 in the foreign matter adhering to the front face of the semiconductor wafer 2 and the trench hole 3 is the same as that of operation of drawing 1 .

[0010] Next, the frequency (MHZ) of the ultrasonic wave for removing the foreign matter 1 in the trench hole 3 and the relation of power (W/cm<sup>2</sup>) are explained with reference to drawing 3 and drawing 4 . first, in order to remove the foreign matter 1 in the trench hole 3 (A) In order to tell energy to the molecular flow 13 of a penetrant remover 5 into the trench hole 3, Ultrasonic wave with oscillating width of face smaller than the path of the trench hole 3 (B) \*\* which a penetrant remover 5 writes by the molecular flow 13 of the penetrant remover 5 of vibrating the foreign matter 1 in the trench hole 3 by the molecular flow 13 of a penetrant remover 5, and making it exfoliate and the trench hole 3 is accelerated. In order to discharge a foreign matter 1 out of the trench hole 3, on the front face of the semiconductor wafer 2 with a perpendicular (level to the trench hole 3) And ultrasonic wave with oscillating width of face of the same grade as a foreign matter 1 (C) \*\* which the penetrant remover 5 in the front face of the semiconductor wafer 2 writes the foreign matter 1 discharged by the front face of the semiconductor wafer 2 by the molecular flow 13 of a penetrant remover 5 is accelerated. Since it keeps away from the front face of the semiconductor wafer 2, it is possible by the ultrasonic wave with oscillating width of face of the same grade as a foreign matter 1 at a level with the front face of the semiconductor wafer 2 (perpendicular to the trench hole 3). Then, sound power of an ultrasonic wave (I:W/cm<sup>2</sup>) The relation between frequency (f) and the molecular vibration width of face (A:cm) of a penetrant remover 5 can be shown below.

[0011]  $I = PC (2\pi f A)^{2/2}$ , however P are the density (g/cm<sup>3</sup>) (in the case of water, it is 1) of a penetrant remover (5).

C is acoustic velocity (cm/S) (in the case of water, it is  $1.5 \times 10^5$  (cm/S)).

[0012] Frequency of 800kHz from the above-mentioned formula and sound power 7.5 W/cm<sup>2</sup> in order to obtain liquid molecular vibration width of face of 0.06 micrometers noting that the 0.06-micrometer foreign matter 1 in the 1-micrometer trench hole 3 of width of face is removed efficiently It is required. And the relation between the frequency in the case of obtaining oscillating width of face of 0.01 micrometers, 0.06 micrometers, and 0.5 micrometers and sound power is shown in drawing 4 . Moreover, it is necessary to add the ultrasonic wave which has a vertical component and a horizontal component for the acoustic energy of the frequency of 100kHz - 10MHz, and 0.01 - 4,000 W/cm<sup>2</sup> to the trench hole 3 for removing the foreign matter (0.5 micrometers - 0.01 micrometers) in the 1-micrometer trench hole (3) of width of face to a wafer front face.

[0013]

[Effect of the Invention] As explained to the detail above, according to the washing method of the semiconductor device concerning this invention, there is an effect which exfoliates in the kinetic energy of the liquid by the ultrasonic wave and the liquid flow, and can discharge completely outside the foreign matter adhering to the hole, Mizouchi, and the front face which were formed in the semiconductor wafer.

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[Translation done.]

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## 2. EFFECT OF THE INVENTION

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[Effect of the Invention] As explained to the detail above, according to the washing method of the semiconductor device concerning this invention, there is an effect which exfoliates in the kinetic energy of the liquid by the ultrasonic wave and the liquid flow, and can discharge completely outside the foreign matter adhering to the hole, Mizouchi, and the front face which were formed in the semiconductor wafer.

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[Translation done.]

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## 3. CLAIMS

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[Claim(s)]

[Claim 1] The washing method of the semiconductor device characterized by irradiating an ultrasonic wave with a horizontal component and a vertical component to the hole and slot which were formed in the semiconductor wafer, vibrating a liquid molecule, and washing.

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[Translation done.]

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## 1. EXAMPLE

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[Example] **Drawing 1** is drawing showing one example of the washing method of the semiconductor device concerning this invention, and especially **drawing 1** (a) is drawing for the cross-section side elevation, **drawing 1** (b), and **drawing 1** (c) explaining washing operation in **drawing 1** (a). The washing tub into which 4 put the penetrant remover 5 in this drawing, and 6 are the cases where were the ultrasonic wave oscillator which outputs an ultrasonic wave 7, are the case where a ultrasonic wave oscillator 6 is attached, made the anchoring wall surface of the washing tub 4 to have been attached in the wall surface of this washing tub 4, and incline as an example so that an ultrasonic wave 7 may irradiate the front face of the semiconductor wafer 2 at an angle of predetermined as an example, and a ultrasonic wave oscillator 6 is attached.

[0007] Next, the inside of the washing method of the semiconductor device by the above-

mentioned composition, especially the trench hole 3 is washed, and operation which removes a foreign matter is explained with reference to **drawing 1** (b) and **drawing 1** (c). First, if it sees from the front face of the semiconductor wafer 2 with the trench hole 3, an ultrasonic wave 7 can be divided into horizontal component 7a and vertical-component 7b to the trench hole 3, as shown in **drawing 1** (b). Therefore, as shown in **drawing 1** (c), horizontal component 7a of this ultrasonic wave 7 vibrates the penetrant remover 5 in the trench hole 3 to horizontal direction 8a, makes the foreign matter 1 in a trench 3 exfoliate, and discharges a foreign matter outside the trench hole 3. On the other hand, vertical-component 7b of an ultrasonic wave 7 vibrates the penetrant remover 5 in the trench hole 3 to perpendicular direction 8b; as shown in **drawing 1** (c), and it acts so that the foreign matter 1 discharged by the front face of the semiconductor wafer 2 may be kept away from the front face of the semiconductor wafer 2.

[0008] In addition, by making it 20 - about 70 degrees, the degree of setting angle of the ultrasonic wave oscillator 6 to the semiconductor wafer 2 exfoliates efficiently, and can discharge the foreign matter 1 in the trench hole 3. It is [0009] without the inside of a trench 3 and a semiconductor wafer front face. [ at **drawing 7** , wash by (SC-1)+ (MS) for 10 minutes, and are the case washed with the pure water rinse for 5 minutes where it after self-\*\*, and ] [ remains of particle ] **Drawing 2** is drawing showing other examples of the washing method of the semiconductor device concerning this invention, and especially **drawing 2** (a) is drawing for the cross-section side elevation, **drawing 2** (b), and **drawing 2** (c) explaining washing operation in **drawing 2** (a). Set to this drawing. The 1st ultrasonic wave oscillator which outputs the horizontal ultrasonic wave 10 to the trench hole 3 9a-9d, and 11 are the 2nd ultrasonic wave oscillator which outputs the vertical ultrasonic wave 12 to the trench hole 3. In addition, of course, operation which exfoliates and removes the foreign matter 1 in the foreign matter adhering to the front face of the semiconductor wafer 2 and the trench hole 3 is the same as that of operation of **drawing 1** .

[0010] Next, the frequency (MHZ) of the ultrasonic wave for removing the foreign matter 1 in the trench hole 3 and the relation of power (W/cm<sup>2</sup>) are explained with reference to **drawing 3** and **drawing 4** . first, in order to remove the foreign matter 1 in the trench hole 3 (A) In order to tell energy to the molecular flow 13 of a penetrant remover 5 into the trench hole 3, Ultrasonic wave with oscillating width of face smaller than the path of the trench hole 3 (B) \*\* which a penetrant remover 5 writes by the molecular flow 13 of the penetrant remover 5 of vibrating the foreign matter 1 in the trench hole 3 by the molecular flow 13 of a penetrant remover 5, and making it exfoliate and the trench hole 3 is accelerated. In order to discharge a foreign matter 1 out of the trench hole 3, on the front face of the semiconductor wafer 2 with a perpendicular (level to the trench hole 3) And ultrasonic wave with oscillating width of face of the same grade as a foreign matter 1 (C) \*\* which the penetrant remover 5 in the front face of the semiconductor wafer 2 writes the foreign matter 1 discharged by the front face of the semiconductor wafer 2 by the molecular flow 13 of a penetrant remover 5 is accelerated. Since it keeps away from the front face of the semiconductor wafer 2, it is possible by the ultrasonic wave with oscillating width of face of the same grade as a foreign matter 1 at a level with the front face of the semiconductor wafer 2 (perpendicular to the trench hole 3). Then, sound power of an ultrasonic wave (I:W/cm<sup>2</sup>) The relation between frequency (f) and the molecular vibration width of face (A:cm) of a penetrant remover 5 can be shown below.

[0011]  $I = \rho C (2\pi f A)^2 / 2$ , however P are the density (g/cm<sup>3</sup>) (in the case of water, it is 1) of a penetrant remover (5).

C is acoustic velocity (cm/S) (in the case of water, it is  $1.5 \times 10^5$  (cm/S)).

[0012] Frequency of 800kHz from the above-mentioned formula and sound power 7.5 W/cm<sup>2</sup> in order to obtain liquid molecular vibration width of face of 0.06 micrometers noting that the 0.06-micrometer foreign matter 1 in the 1-micrometer trench hole 3 of width of face is removed efficiently It is required. And the relation between the frequency in the case of obtaining oscillating width of face of 0.01 micrometers, 0.06 micrometers, and 0.5 micrometers and sound power is shown in **drawing 4** . Moreover, it is necessary to add the ultrasonic wave which has a vertical component and a horizontal component for the acoustic energy of the frequency of 100kHz - 10MHz, and 0.01 - 4,000 W/cm<sup>2</sup> to the trench hole 3 for removing the foreign matter (0.5 micrometers - 0.01 micrometers) in the 1-micrometer trench hole (3) of width of face to a wafer front face.

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[Translation done.]

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## 1. DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

**[Drawing 1]** It is drawing showing one example of the washing method of the semiconductor device concerning this invention.

**[Drawing 2]** It is drawing showing other examples of the washing method of the semiconductor device concerning this invention.

**[Drawing 3]** It is drawing showing the method of tailing in the trench hole of a semiconductor wafer.

**[Drawing 4]** It is drawing showing the relation between the molecular vibration width of face of liquid, and an ultrasonic acoustic energy and frequency.

**[Drawing 5]** It is drawing showing the standard pollution sample of the foreign matter in a trench hole.

**[Drawing 6]** It is drawing showing the case where the inside of a trench hole and a wafer front face are washed by the washing method of the conventional semiconductor device.

**[Drawing 7]** It is drawing showing the case where the inside of a trench hole and a wafer front face are washed by the washing method of the semiconductor device concerning this invention.

[Description of Notations]

- 1 Foreign Matter
- 2 Semiconductor Wafer
- 3 Trench Hole
- 4 Washing Tub
- 5 Penetrant Remover
- 6 Ultrasonic Wave Oscillator
- 7 Ultrasonic Wave
- 8a, 8b The oscillating direction of a penetrant remover
- 10 12 Ultrasonic wave

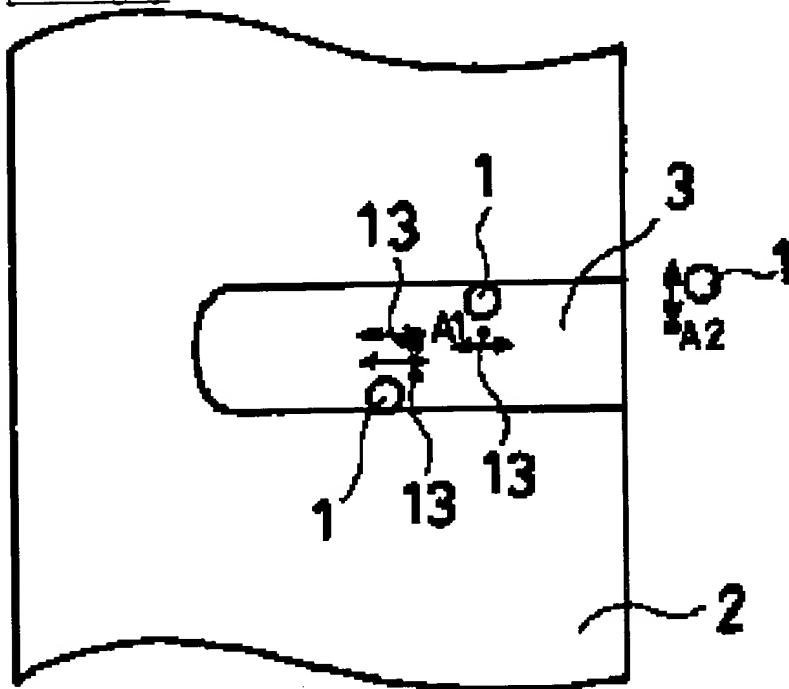
109  
11

9a- 9b and 11 Ultrasonic wave oscillator

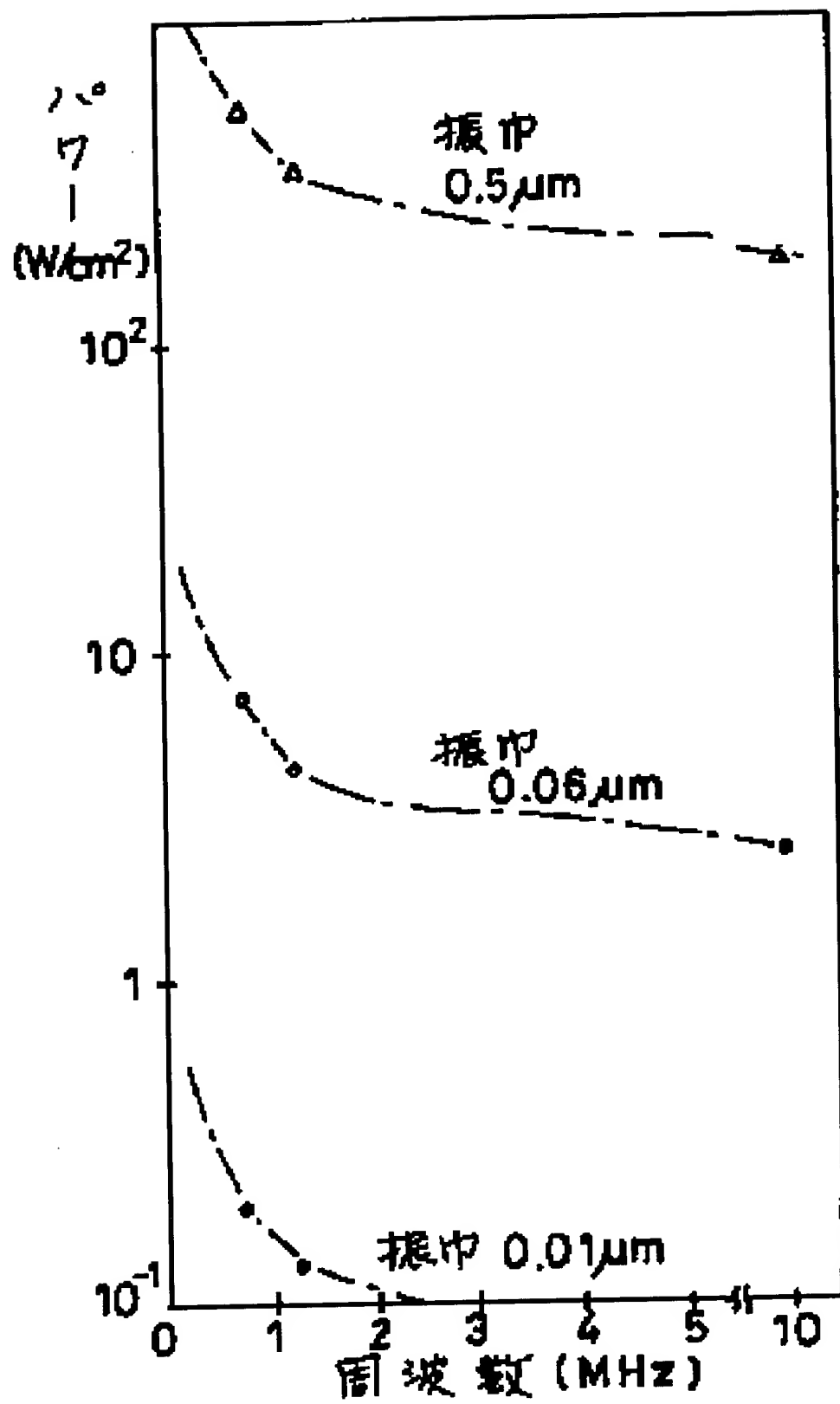
[Translation done.]

## 1. DRAWINGS

[Drawing 3]

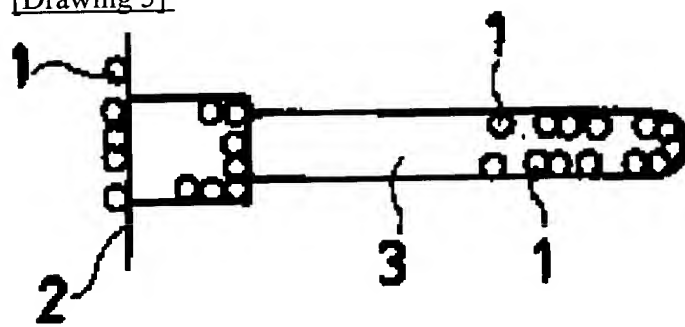


[Drawing 4]

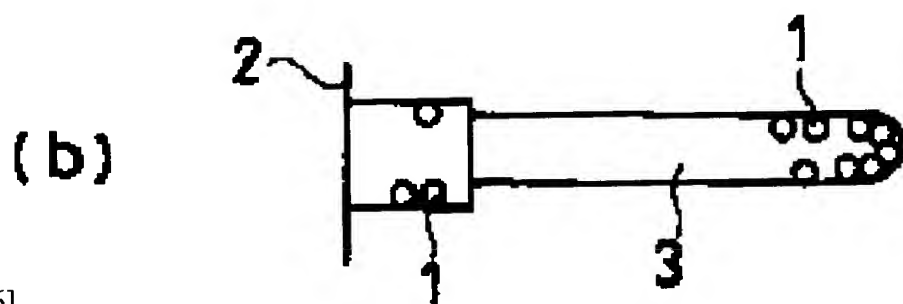
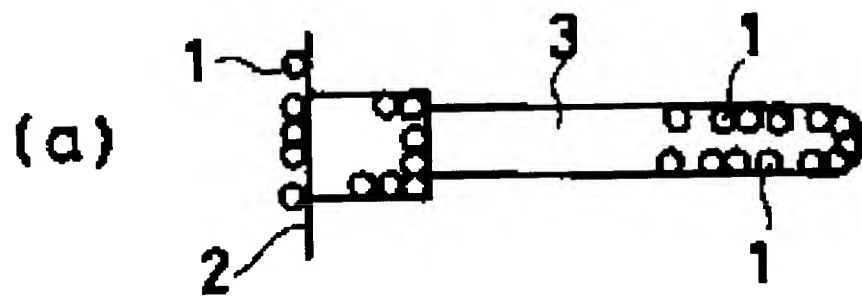




[Drawing 5]

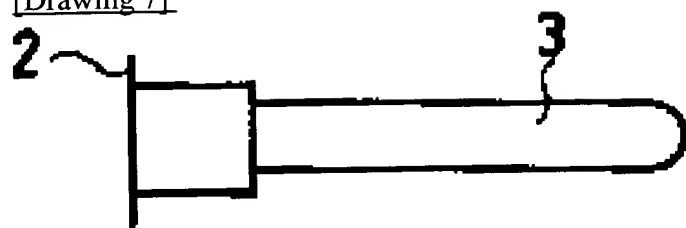


[Drawing 6]

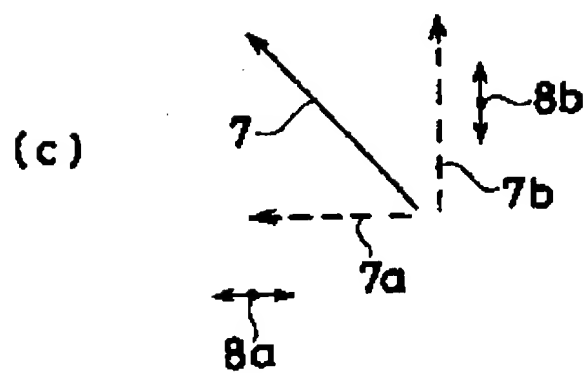
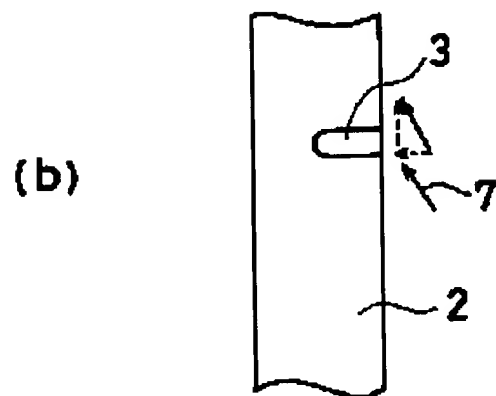
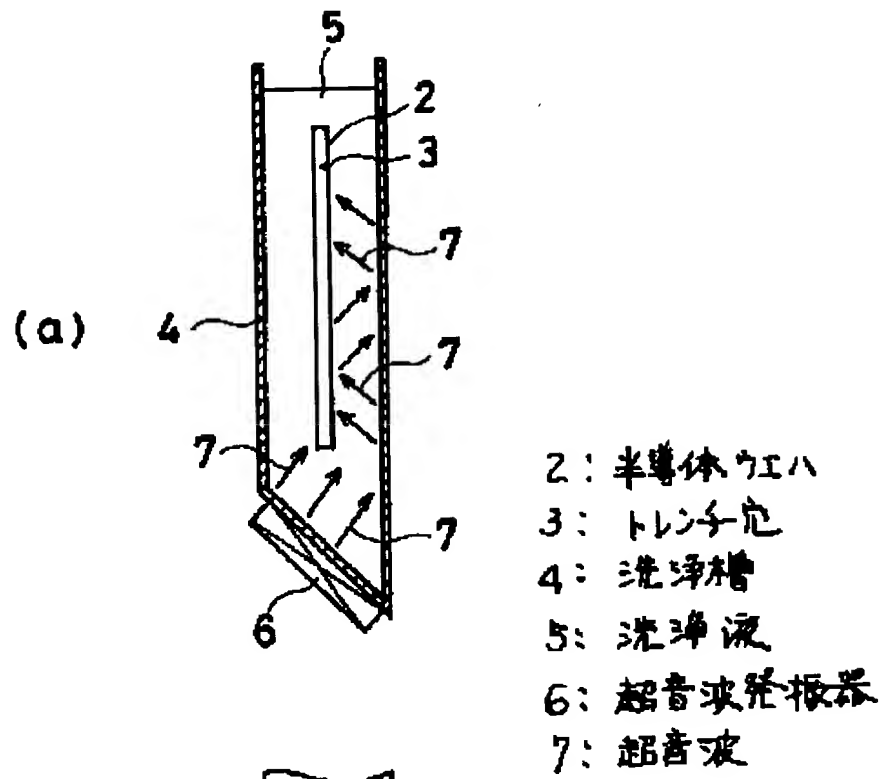


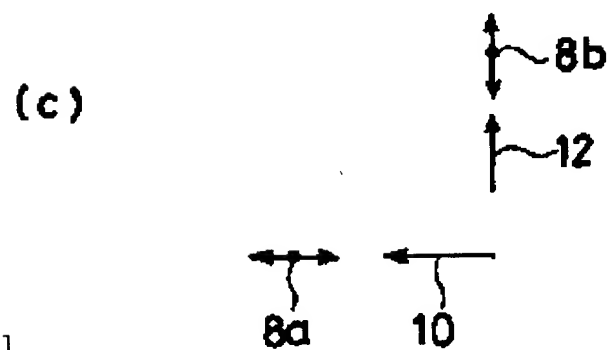
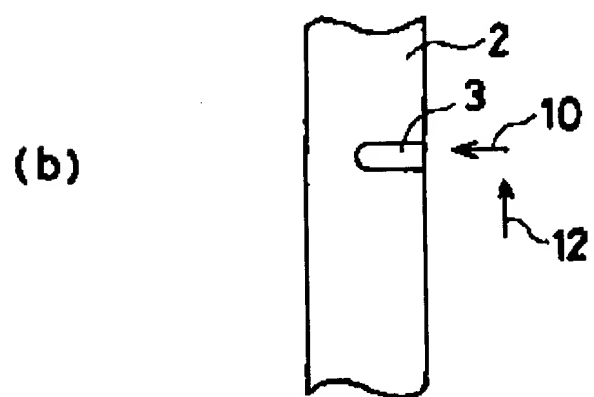
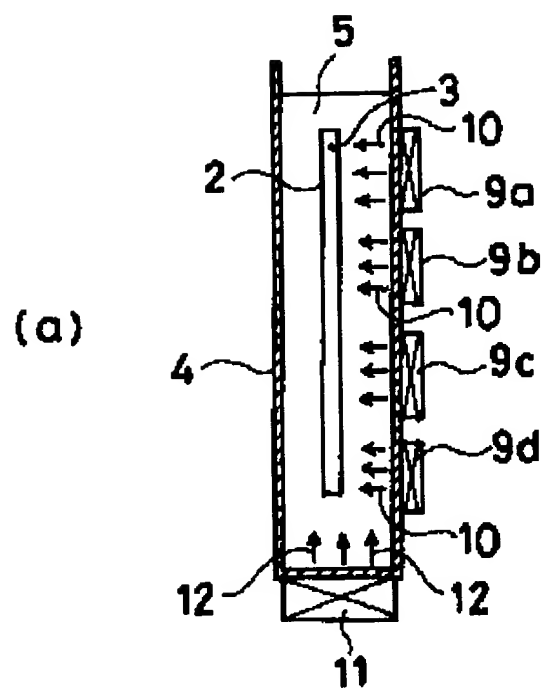
66]

[Drawing 7]



[Drawing 1]





## CORRECTION or AMENDMENT

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[Official Gazette Type] Printing of amendment by the convention of 2 of Article 17 of patent law.

[Section partition] The 2nd partition of the 7th section.

[Date of issue] July 2, Heisei 11 (1999).

[Publication No.] Publication number 5-13396.

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[Filing Number] Japanese Patent Application No. 3-167844.

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H01L 21/304 341 .

[FI]

H01L 21/304 341 T .

[Procedure revision]

[Filing Date] April 9, Heisei 10.

[Procedure amendment 1]

[Document to be Amended] Specification.

[Item(s) to be Amended] Claim 1.

[Method of Amendment] Change.

[Proposed Amendment]

[Claim 1] The washing method of the semiconductor device characterized by irradiating an ultrasonic wave with the horizontal component and vertical component of oscillating width of face of the same grade as the size of the foreign matter which is in the inside of the aforementioned hole or a slot in a penetrant remover to the hole and slot which were formed in the semiconductor wafer, vibrating the liquid molecule of the aforementioned penetrant remover, and washing.

[Procedure amendment 2]

[Document to be Amended] Specification.

[Item(s) to be Amended] 0004.

[Method of Amendment] Change.

[Proposed Amendment]

[0004]

[Means for Solving the Problem] The washing method of the semiconductor device concerning this invention irradiates an ultrasonic wave with the horizontal component and vertical component of oscillating width of face of the same grade as the size of the foreign matter which is in the inside of the aforementioned hole or a slot in a penetrant remover to the hole and slot which were formed in the semiconductor wafer, vibrates the liquid molecule of the aforementioned penetrant remover, and is washed.

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[Translation done.]